| Surname | Centre Number | Candidate Number |
|---|---|---|
| First name(s) | | 2 |

# GCE AS

B400U20-1

S24-B400U20-1

**THURSDAY, 23 MAY 2024 – MORNING**

## BIOLOGY – AS component 2
### Biodiversity and Physiology of Body Systems

1 hour 30 minutes

| For Examiner's use only | | |
|---|---|---|
| **Question** | **Maximum Mark** | **Mark Awarded** |
| **1.** | **14** | |
| **2.** | **14** | |
| **3.** | **9** | |
| **4.** | **15** | |
| **5.** | **14** | |
| **6.** | **9** | |
| **Total** | **75** | |

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01

**ADDITIONAL MATERIALS**

A calculator and a ruler.

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

**INFORMATION FOR CANDIDATES**

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

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Answer **all** questions.

**1.** Coral reefs are extremely biodiverse ecosystems.

(a) Damselfish (family *Pomacentridae*) are common on coral reefs. Often, several species with different body shapes and colour patterns inhabit a single reef.

**Image 1.1** shows five species of damselfish that live on one coral reef.

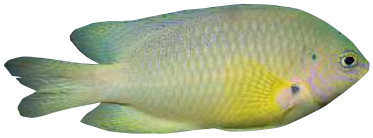
**Image 1.1**



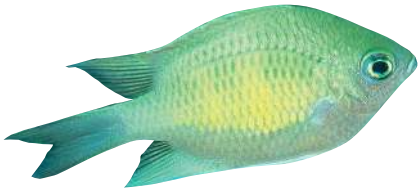
**A.** *Chromis viridis*



**B.** *Dascyllus aruanus*



**C.** *Pomacentrus amboinensis*



**D.** *Amblyglyphidodon curacao*



**E.** *Dascyllus reticulatus*

(i) Use information from **Image 1.1** and letters **A–E** to state which species are most closely related and explain your answer. [1]

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(ii) Many related species of damselfish live close together within the same reef. Explain why they are classified as separate species. [1]

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Damselfish diversity on a coral reef was investigated using the following method.

In daylight hours during one day:

- Capture the damselfish within a measured sample area using nets.
- Count all the individuals of each species.
- Release them in the same place they were captured.

The number of each species ($n$) is shown in **Table 1.2**.

**Table 1.2**

| Damselfish species | $n$ | $n$–1 | $n(n–1)$ |
|---|---|---|---|
| *Chromis viridis* | 63 | 62 | 3906 |
| *Dascyllus aruanus* | 38 | 37 | 1406 |
| *Pomacentrus amboinensis* | 34 | 33 | 1122 |
| *Amblyglyphidodon curacao* | 47 | 46 | 2162 |
| *Dascyllus reticulatus* | 23 | 22 | 506 |
| $N$ = | ..... | $\sum n(n–1)$ = | ..... |
| $N(N–1)$ = | ..... | | |

(iii) Calculate the diversity index of damselfish in this area of reef using **Table 1.2** and Simpson's Diversity Index equation. [3]

$$D = 1 - \frac{\sum n(n–1)}{N(N–1)}$$

**Key:**

$N$ = total number of organisms present

$n$ = number of each species

$\sum$ = sum of

D = .....

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(iv) Suggest **two** possible sources of error in this method which may reduce confidence in the diversity value calculated for the whole reef. [2]

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(b) The diversity of corals living within the reef was also investigated.

- A 250 $m^2$ area was sampled using 1 $m^2$ quadrats.
- 10 quadrats were placed at points selected randomly within the area.
- The percentage cover of five dominant species of coral within each quadrat was estimated and a mean calculated.

(i) The same scuba diver estimated the percentage cover in each quadrat. Give a reason why this was important for the accuracy of the method. [1]

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The mean percentage cover was used to calculate the total area covered by each species within the measured 250 $m^2$.

**Table 1.3** shows the area covered by five species of coral in 250 $m^2$ of reef.

**Table 1.3**

| Coral species | Total area of coral within a 250 $m^2$ area of reef / $m^2$ |
|---|---|
| *Acropora spathulata* | 25 |
| *Acropora intermedia* | 21 |
| *Seriatopora hystrix* | ..... |
| *Pocillopora damicornis* | 42 |
| *Stylophora pistillata* | 36 |

(ii) The mean percentage cover for *Seriatopora hystrix* was calculated to be 12%. Calculate the total area occupied by *S. hystrix* within the 250 $m^2$ area of reef sampled. **Write your answer** in **Table 1.3**. [1]

Space for working





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(c) Many damselfish species live between the branches of coral, where they feed on algae and obtain protection from predatory fish. They also feed on suspended plankton away from the coral but never swim far beyond it.

**Image 1.4** shows a population of *Chromis viridis* around a colony of coral.

**Image 1.4**




The spacing size between branches of host coral affects damselfish survival.

In an investigation:

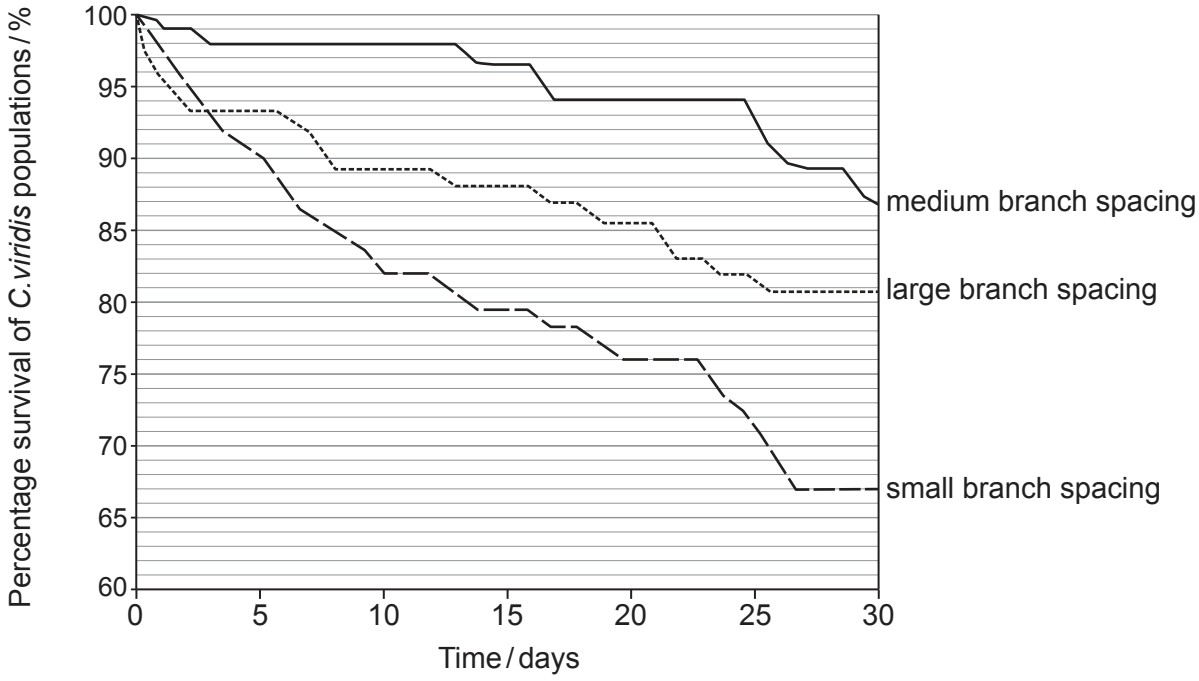
- *S. hystrix* corals with the same diameter were monitored from the time of initial colonisation by a population of young *C. viridis*.
- Each coral was identified as having either large, medium or small branch spacing.
- The number of fish within each coral was counted every day for 30 days.
- The percentage of the initial population surviving after each day was calculated.


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**Graph 1.5** shows percentage survival for *C. viridis* populations within three sizes of coral branch spacing.

**Graph 1.5**




(i) State why data in **Graph 1.5** is expressed as a percentage rather than number of fish surviving. [1]

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The DNA of *C. viridis* on this reef was found to have high numbers of polymorphic alleles that control growth.

(ii) Describe what is meant by the term 'polymorphic alleles'. [1]

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(iii) Some alleles that cause increased growth were present at lower frequencies in populations of *C. viridis* living within corals with small branch spacing.

Use the information given in part (c) to suggest how the biodiversity of these populations has been affected by natural selection and explain your answer. [3]

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**2.** Polar bears (*Ursus maritimus*) and cows (*Bos taurus*) are mammals that need a great deal of protein and energy in order to grow their large mass of tissue.

Polar bears are carnivores that live in the Arctic Circle. Their prey includes seals, which provide a diet high in proteins and lipids.

**Image 2.1** shows the skull of a polar bear.

**Image 2.1**



(a) Identify **two** features, visible in **Image 2.1**, that show adaptations to the polar bear's carnivorous diet. Explain how each is an adaptation for such a diet. [2]

Feature 1: .....

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Feature 2: .....

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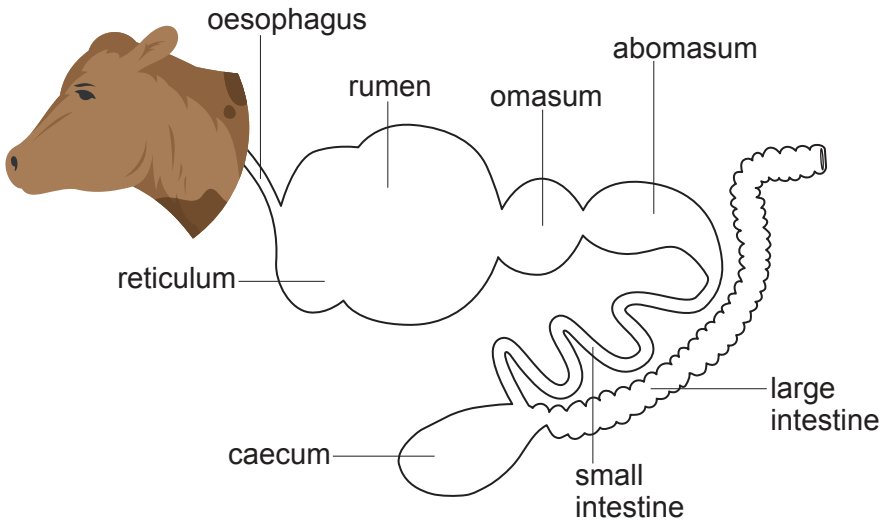


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(b) Cows are herbivores. Their diet is almost exclusively grass, which has a high cellulose content and very little protein. **Image 2.2** is a diagram of the digestive system of a cow.

**Image 2.2**




(i) The contents of the abomasum have a pH of 2 due to the secretion of hydrochloric acid. The abomasum has the same function as the stomach of polar bears (carnivores) and humans (omnivores).

Name **one** enzyme produced by the abomasum and explain **one** reason why the contents of the abomasum need to have a low pH. [2]

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(ii) The rumen contains many types of micro-organism. An adult cow had a rumen capacity of $1.6 \times 10^4\,cm^3$ of fluid. In a sample of the rumen fluid, micro-organisms made up 3.6% of the volume. The proportion of micro-organisms that were bacteria was $10^{10}\,cm^{-3}$.
Calculate the number of bacteria present in the rumen of this individual. **Give your answer in standard form**. [3]

Number of bacteria = .....

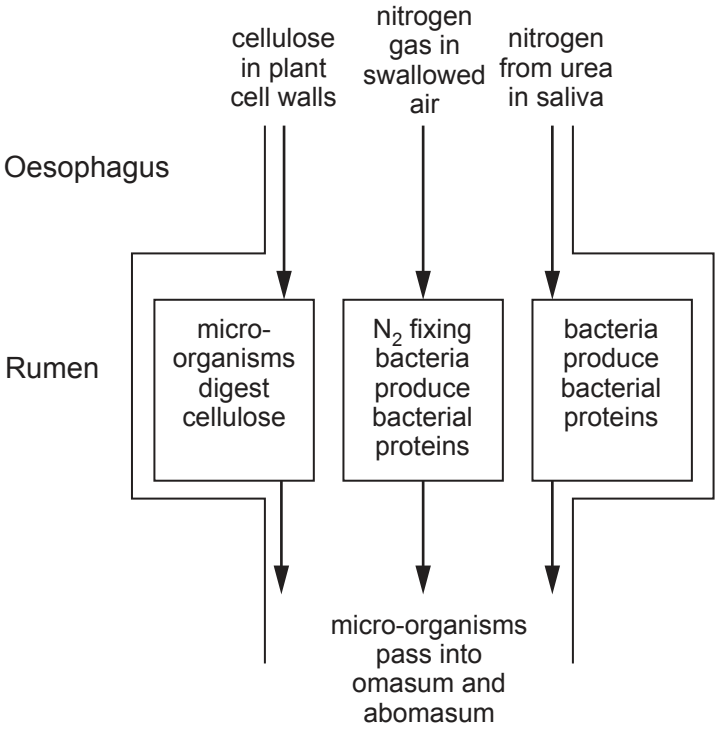


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**Image 2.3** illustrates the function of some of the micro-organisms in the rumen.

**Image 2.3**




(iii) Using **Image 2.3** and your answer to (b)(ii), suggest how the cow obtains **sufficient** amino acids to produce its own proteins. [2]

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The rumen contains single-celled protoctists that consume other micro-organisms or particles of plant matter swallowed by the cow.

**Image 2.4** is a photograph of a rumen protoctist containing several food vacuoles. Following endocytosis, it carries out intracellular digestion.

**Image 2.4**




(iv) Describe the process of digestion inside the cell after the formation of the food vacuole. [2]

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(c) Enzymes on the plasma membrane of epithelial cells in the small intestine hydrolyse tripeptides and dipeptides.

(i) Suggest **one** advantage of using membrane-bound enzymes at this stage of digestion. [1]

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(ii) Describe and explain how **one** structural feature of the small intestine increases the efficiency of protein digestion. [2]

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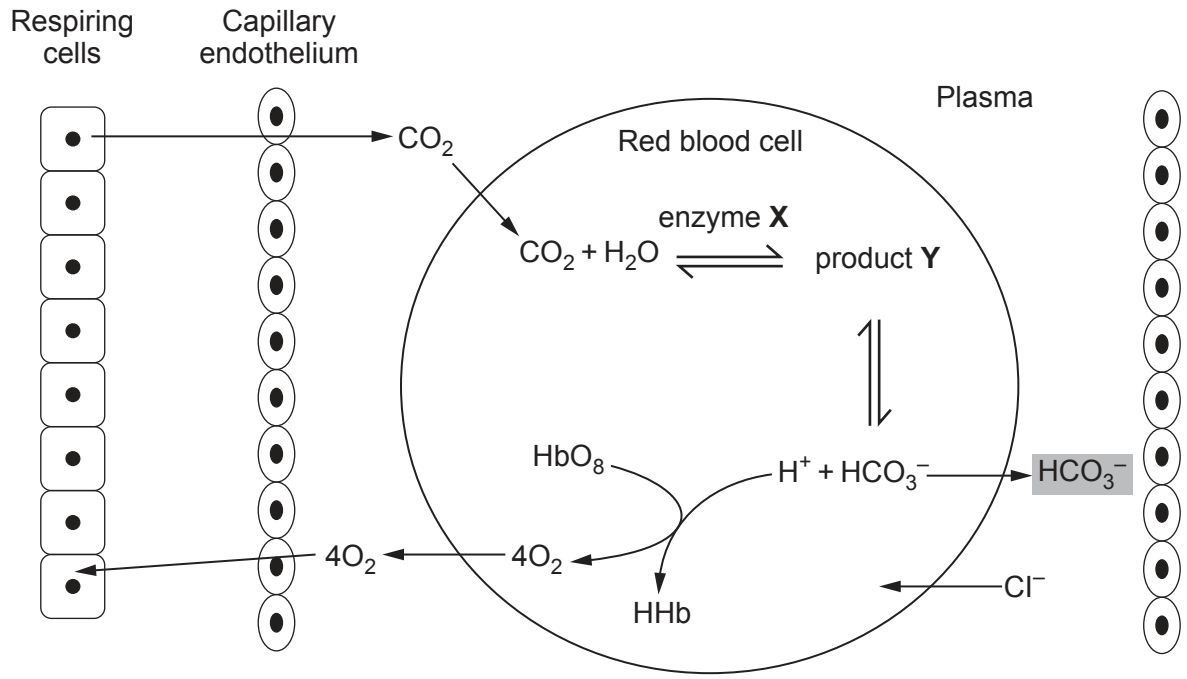


**Turn over.**

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**3.** (a) Most of the carbon dioxide produced by mammalian cells is transported in hydrogen carbonate ions ($HCO_3^-$) in blood plasma. The mechanism of $HCO_3^-$ production is shown in **Image 3.1**.

**Image 3.1**




(i) Identify enzyme **X** and product **Y** in **Image 3.1**. [1]

Enzyme **X**: .....

Product **Y**: .....

(ii) Use **Image 3.1** to describe how haemoglobin prevents blood pH from becoming too low. [1]

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(iii) State the function of chloride ions ($Cl^-$), shown in **Image 3.1**. [1]

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(iv) State **one** way that carbon dioxide can be transported in the blood other than that described in **Image 3.1**. [1]

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(b) In insects, carbon dioxide from muscles is exchanged into tracheoles that penetrate muscle cells. Spiracles open when partial pressure of $CO_2$ ($ppCO_2$) in tracheoles reaches a critical threshold and close when $ppCO_2$ falls below the critical threshold.

Insect body temperature changes with environmental temperature.

Scientists investigated the effect of body temperature on ventilation in *Rhodnius prolixus*, an insect that feeds by sucking blood from mammals. This is shown in **Image 3.2**.

**Image 3.2**



- Ten *R. prolixus* of the same age and body mass were obtained.
- One individual was selected randomly and placed into a 2 $cm^3$ tube.
- The temperature in the tube was maintained at 18°C for one hour before making recordings.
- Atmospheric air (at 18°C) flowed in through a valve and out through a gas analyser.
- The following information was recorded for 30 seconds:
    - Length of time spiracles were open.
    - Length of each ventilation cycle.
    - Volume of $CO_2$ released.

The experiment was repeated at 24 °C and 30 °C, using the same insect.

(i) State why the insect was left for one hour at the experimental temperature before recording data. Explain your answer. [2]

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To prevent $CO_2$ production increasing as a result of feeding, insects were not fed for 24 hours prior to the experiment.

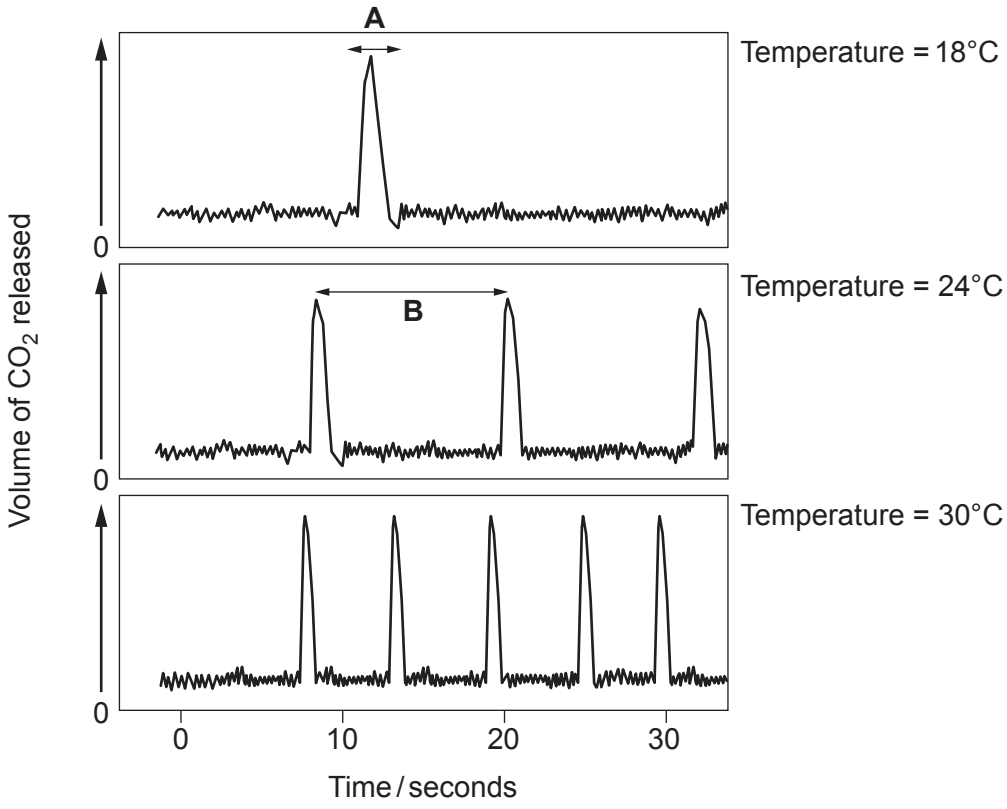
(ii) Suggest **one** reason why feeding might increase $CO_2$ production in these insects. [1]

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**Image 3.3** shows recordings from the experiment.

**Image 3.3**




**A** – Length of time spiracle is open

**B** – Length of one ventilation cycle



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(iii) With reference to the **partial pressure of carbon dioxide** in the tracheoles, explain the reason for the following trends observed in **Image 3.3**. [2]

Trend I: As temperature increases, length of the ventilation cycle decreases.

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Trend II: As temperature increases, length of time the spiracle is open decreases.

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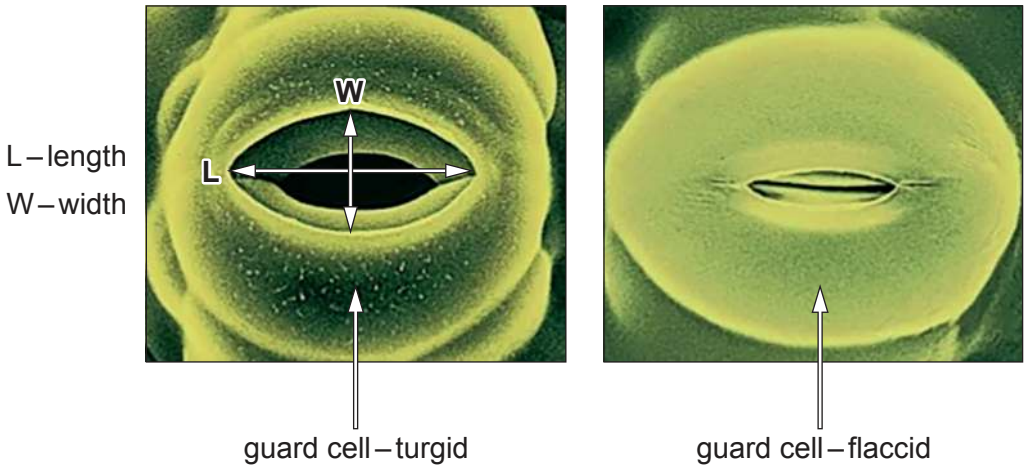
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**4.** (a) The presence of stomata on leaves has helped plants to colonise terrestrial environments.

**Images 4.1A** and **4.1B** show electron photomicrographs of stomata on the same leaf at midday and midnight.

**Image 4.1A Fully open** — midday

**Image 4.1B Fully closed** — midnight




(i) Explain the advantage of closing stomata at night and why the plant is at a disadvantage if the stomata were to close at midday. [2]

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(ii) Guard cells in **Image 4.1A** are turgid. ATP is required for them to achieve this state. Describe the mechanism that enables guard cells to become turgid. [3]

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(b) (i) One way to measure the extent of stomatal opening is to calculate the aspect ratio.

$$\text{Aspect ratio (AR)} = \frac{\text{length of stomatal opening (L)}}{\text{width of stomatal opening(W)}}$$

The aspect ratio of an open stoma was found to be 1.75 : 1.
The length (L) was 63 µm.

Calculate the width of the stoma (W). [2]

Width of stoma = ..... µm

(ii) A student produced a scale drawing of the stoma and guard cells described in (b)(i) and drew a line to represent the length of the stoma (L). This line measured 31.5 mm.

Calculate the magnification of the drawing. [2]

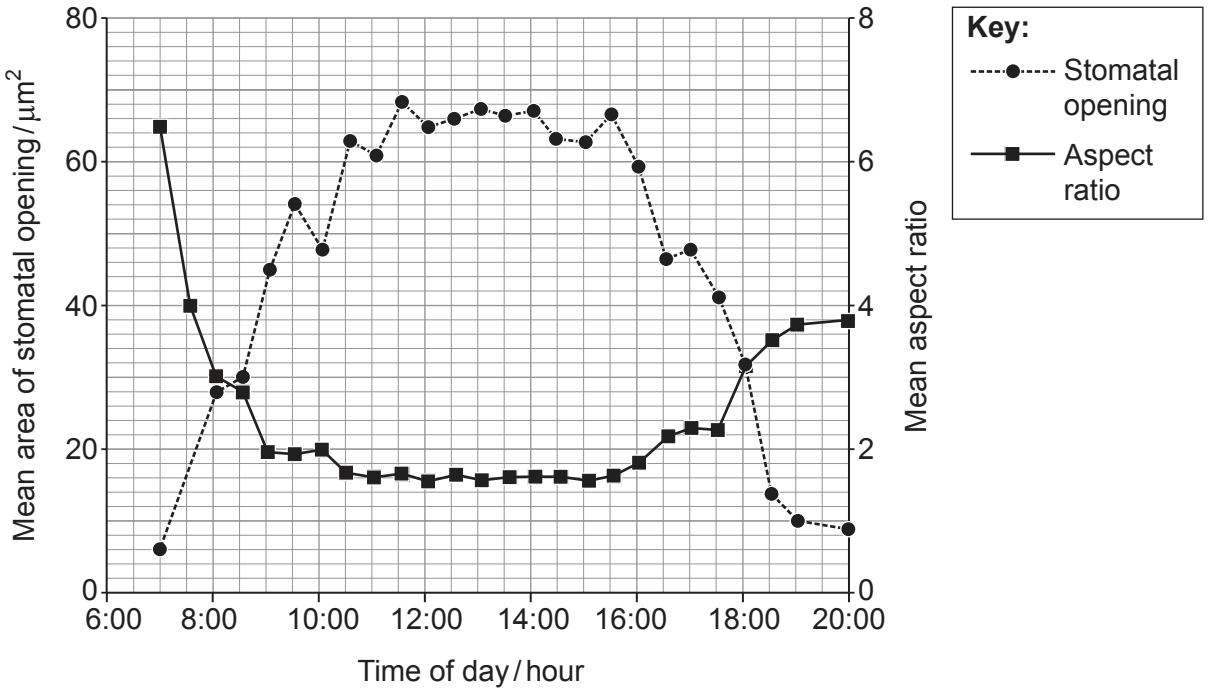
Magnification = × .....


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**Graph 4.2** shows the mean area of stomatal opening and the mean aspect ratio of stomata between 07:00 and 20:00 during a single day.

**Graph 4.2**




(iii) Suggest why calculating aspect ratio gives a more precise measurement of the extent to which stomata are open than measuring the width or length of the stoma. [1]

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(iv) The lowest aspect ratio value in **Graph 4.2** is greater than 1. With reference to the shape of the stomata in **Image 4.1A**, suggest why a value of 1 is unlikely. [1]

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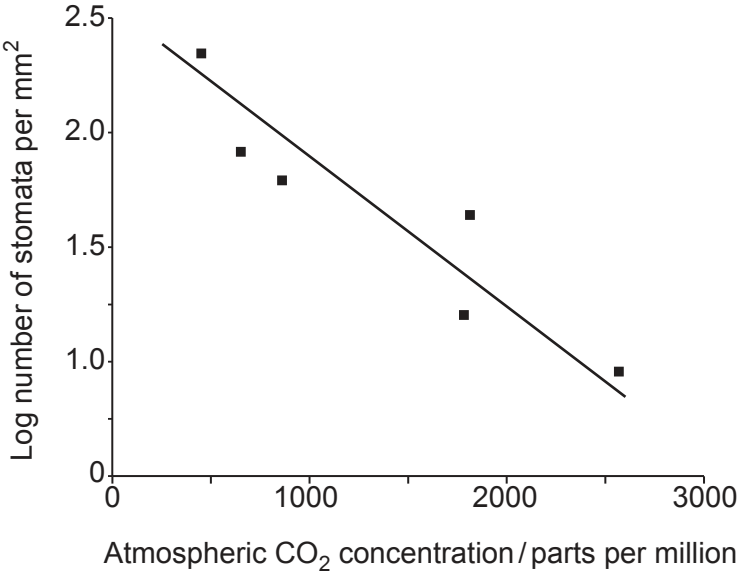
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(c) Atmospheric $CO_2$ concentration has varied during the course of plant evolution. Fossil records show that the density of stomata (number per unit area) has changed in many species over time.

**Graph 4.3** shows the log number of stomata per $mm^2$ from fossilised leaves against atmospheric $CO_2$ concentrations.

**Graph 4.3**




(i) Use **Graph 4.3** to explain how plants living in lower atmospheric $CO_2$ concentrations were adapted for maximum $CO_2$ uptake. [2]

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Scientists have recorded decreased rainfall in several forested areas of the world and suggest that increasing atmospheric $CO_2$ concentration is a potential cause.

(ii) If atmospheric $CO_2$ concentration continues to increase over time, predict the effect on the stomata of some plant species and suggest why it could cause a reduction in cloud formation and rainfall near forests. [2]

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**5.** (a) Insects have open circulatory systems. Their body cavity (haemocoel) is filled with fluid that has direct contact with tissues and contains no haemoglobin.

(i) State **one** advantage and **one** disadvantage of an open circulatory system. [2]

Advantage: .....

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Disadvantage: .....

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In mammals, blood is transported in a closed, double circulatory system.

(ii) Describe what is meant by a 'double circulatory system'. [1]

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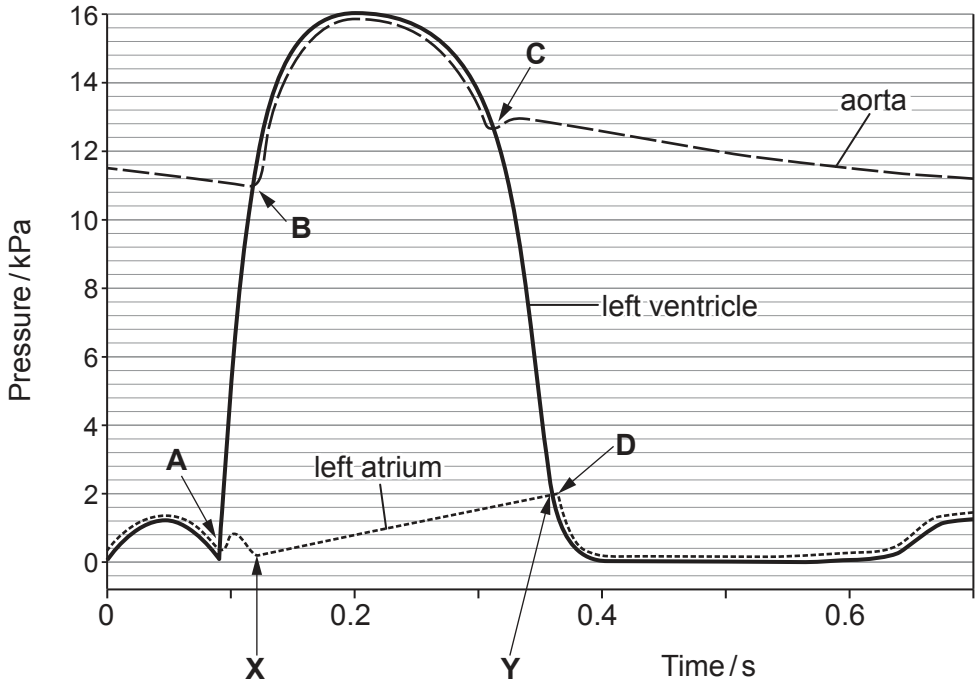


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(b) **Graph 5.1** shows pressure changes of the left side of the heart during one cardiac cycle.

**Graph 5.1**




(i) Use **one** of the letters **A** to **D** on **Graph 5.1** to identify when blood begins to leave the ventricle. Describe **one** piece of evidence from **Graph 5.1** that supports your answer. [2]

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(ii) Explain the increase in pressure within the left atrium between points **X** and **Y**. [1]

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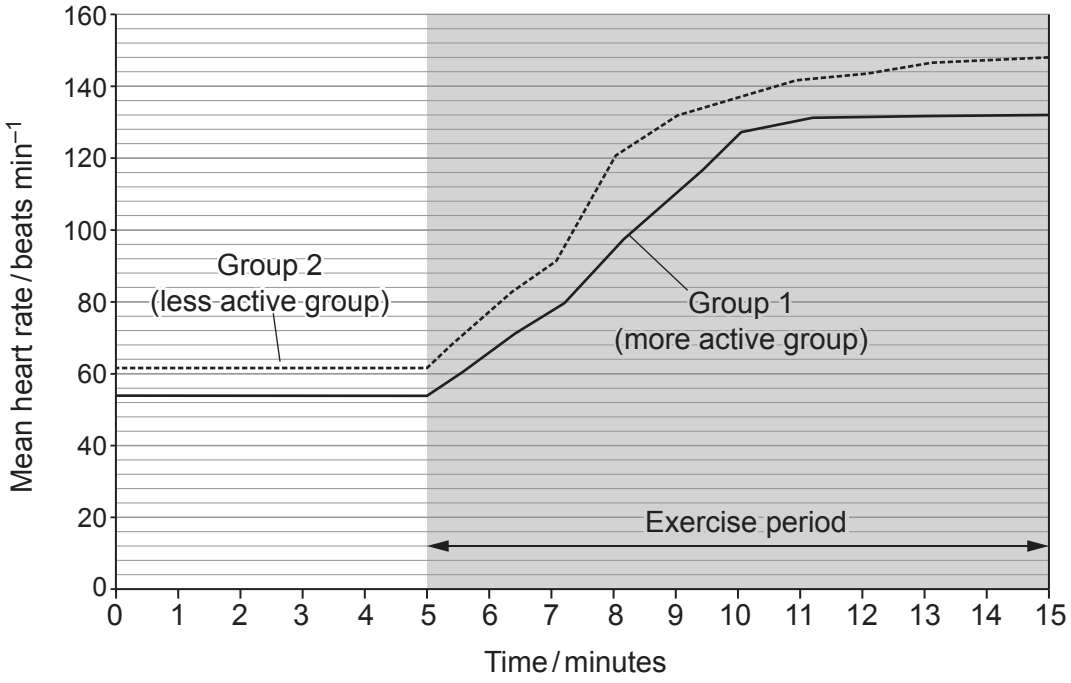
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(c) Scientists investigated the effect of exercise on heart rate in adult males with no history of smoking or cardiovascular disease. Two groups of 50 individuals, aged 18–21, were studied.

Group 1 (more active group) participated in aerobic activity for more than one hour at least 3 times a week.
Group 2 (less active group) participated in aerobic activity for less than one hour each week.

Participants were selected randomly from a larger number of volunteers. The heart rate of each participant was monitored while running on a treadmill for 10 minutes.
The mean heart rate for each group is shown in **Graph 5.2**.

**Graph 5.2**




(i) Data from group 1 showed a large standard deviation (SD).
Describe what is meant by the term 'standard deviation' and explain how the criteria used to place individuals in group 1 could contribute to a large SD value. [2]

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(ii) State **one** feature of the method that increases reliability of the data. [1]

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In addition to the mean maximum heart rate, the following measurements were taken:

- The stroke volume (mean maximum volume of blood leaving the left ventricle per beat).
- The cardiac output (mean maximum volume of blood leaving the left ventricle per minute).

The measurements for each group are shown in **Table 5.3**.

**Table 5.3**

| Group | Mean maximum heart rate / beats $min^{-1}$ | Mean stroke volume (maximum volume of blood leaving the left ventricle per beat) / $dm^3$ | Mean cardiac output (maximum volume of blood leaving the left ventricle per minute) / $dm^3min^{-1}$ |
|---|---|---|---|
| 1 (more active) | 135 | ..... | 24.3 |
| 2 (less active) | 150 | 0.13 | 19.5 |

(iii) Calculate the mean stroke volume for group 1.
Write your answer in **Table 5.3**. [2]

Space for working

(iv) Using your answer to (c)(iii) and the information in **Table 5.3**, explain how the heart achieves a higher cardiac output in individuals in group 1 (more active) than those of group 2 (less active). [2]

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The blood pressure of all participants was recorded before and after the exercise period.

In each group, the mean systolic blood pressure increased from 120 mm Hg to 170 mm Hg during exercise but mean diastolic blood pressure remained at 82 mm Hg.

(v) Explain how **one** property of a tissue in the wall of arteries prevents an excessive fall in blood pressure during diastole. [1]

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**6.** Sunflowers (*Helianthus annuus*) produce large flowers on long stems.

**Image 6.1** shows a transverse section of a sunflower stem.

**Image 6.2** shows a transverse section of a stem of *Potamogeton*, a hydrophytic plant that grows in freshwater ponds. Roots anchor the plant in the ground below water. A stem connects the roots to the leaves which float on the water surface where there is maximum light.

**Image 6.1 – TS *Helianthus* stem**

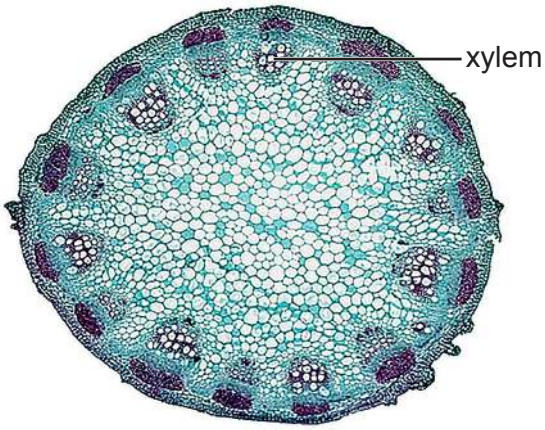
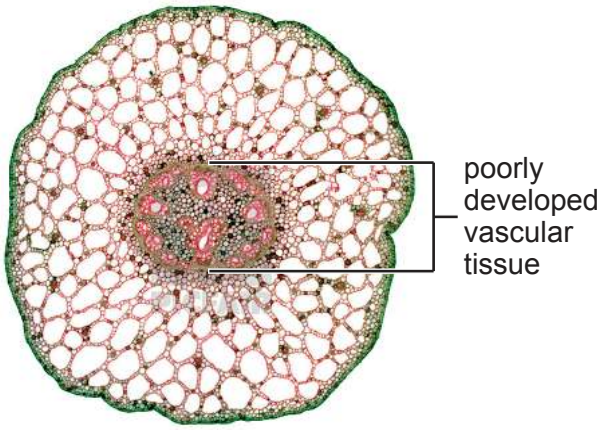



**Image 6.2 – TS *Potamogeton* stem**




Use **Image 6.1** to describe how the structure and position of xylem tissue contribute to its functions in a sunflower stem.

Use the information in **Images 6.1** and **6.2** together with your knowledge of hydrophytes to describe the differences between the stem structures of *Helianthus* and *Potamogeton*.

Explain how the stem structure of *Potamogeton* is adapted to its aquatic environment.

[9 QER]

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